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United States Department of Agriculture,

OFFICE OF EXPERIMENT STATIONS—Circular No. 63.

A. C. True, Director.

THE WORK OF THE OFFICE OF EXPERIMENT STATIONS IN IRRIGATION AND DRAINAGE.

The following statement regarding the work of the Department in irrigation and drainage carried on under the direction of this Office, its relation to the other branches of the Department's work, and its influence on the agricultural development and prosperity of the country was made to the Committee on Irrigation of Arid Lands of the House of Representatives at their request, and was first published as House of Representatives Document No. 381 (58th Cong., 3d sess.). It is now republished to meet the constant demand for general information regarding the work of the Department in these lines.

FEBRUARY 11, 1905.

The committee met this day at 11 o'clock a. m., Hon. FRANK W. MONDELL, chairman, presiding.

The CHAIRMAN. Gentlemen, I think there are a sufficient number of members present to warrant our beginning the hearing. After consultation with several members of the committee, I thought it would be well for us to hear from the gentlemen in the Agricultural Department who have to do with the subject of irrigation, so that if we print these hearings we may have their statements in the printed hearings along with the others heretofore taken.

The Agricultural Department has been doing a very great work, a splendid work, in connection with irrigation. Its work has been in relation to the use of water on lands, with a view to aiding the farmers or irrigators in the attempt to bring about improved methods in the use of water in irrigation. It is a very comprehensive work and a very important work; a work which has been carried on with a great deal of vigor, industry, and intelligence.

We would like to hear from Doctor True as to what his department has been doing along this line.

STATEMENT OF DR. A. C. TRUE, DIRECTOR OFFICE OF EXPERIMENT STATIONS, DEPARTMENT OF AGRICULTURE.

Mr. TRUE. Mr. Chairman and gentlemen of the committee, through the liberality of Congress the irrigation and drainage investigations of the Department of Agriculutre have developed very rapidly during the past two or three years. A large amount of data has been collected, a good deal of which has not been published, and the scope of the investigation has been enlarged. For that reason Secretary Wilson, as well as Doctor Mead and myself, was very glad to receive an invitation to explain our work to this committee, which is charged especially with the work of promoting this work of irrigation.

In order to economize time I have drawn up a brief written statement which I propose to read. But, of course, I shall be glad at any point to have members of the committee ask questions.

Mr. REEDER. I want to ask a question as to the amount of territory covered, and want to know particularly as to how far east these experiments have been looked into—that is, as to the use of water?

Mr. TRUE. We will try to explain that matter quite fully as we go on.

Mr. REEDER. I have been surprised to see the amount of irrigation that is being done in Florida and in Louisiana—States which we supposed were almost humid. But if you include that in your remarks, never mind.

Mr. TRUE. It has been my duty to have supervision of this work, and I shall, therefore, deal with the more general matters relating to it, leaving to Doctor Mead to explain the details more fully.

The irrigation and drainage investigations of the Department of Agriculture are the logical outcome of a general movement in this country for the development of a comprehensive system of agricultural education and research. This movement has made very rapid progress since the establishment of the agricultural experiment stations in all the States and Territories under the act of March 2, 1887

(Hatch Act). These stations have carried their investigations into every branch of agriculture and the data which they have accumulated have made it possible to formulate a true science of agriculture (as distinguished from the fundamental sciences on which it is based) and thus to establish the courses of instruction in our colleges of agriculture on a sound pedagogical basis, and to disseminate among our farmers a large amount of accurate information by which they have been enabled to improve the practice of their art.

The main branches of the science of agriculture are plant production, animal production, agricultural technology, rural engineering, and rural economics. The attempt to formulate this science and to base the instruction in the agricultural colleges upon it has led to specialization of the work of instructors, with the consequent enlargement of the agricultural faculties and a great increase in the number of students. It has also greatly stimulated research along agricultural lines by showing what are deficiencies in our knowledge of agricultural problems and thus presenting numerous definite tasks for agricultural investigators. This has led to the enlargement of the work of the experiment stations and especially of the Department of Agriculture.

When Secretary Wilson took charge of the Department in 1897 he found that its operations covered only a fraction of the field of agricultural science and that its organization was very incomplete. He therefore undertook the reorganization of the Department and the expansion of its work in many directions. This led to the organization of bureaus chiefly along the lines of the division of the science of agriculture, and we now have the Weather Bureau, Bureau of Soils, Bureau of Plant Industry, Bureau of Animal Industry, Bureau of Entomology, Bureau of Chemistry (really a Bureau of Agricultural Technology), and Bureau of Statistics (dealing with subjects in the range of rural economics).

The great subject of rural engineering, which in 1897 was represented in the Department by the small office of road inquiry, has been gradually given increased attention, first by the establishment of irrigation investigations, then by the addition of drainage investigations, and lastly by the beginning of investigations relating to farm structures and machinery, and the use of different kinds of power for agricultural purposes. Aside from the road work, the rural engineering investigations are at present organized as a division of the Office of Experiment Stations, but it is hoped that ere long they will be given a separate organization as a bureau of rural engineering.

These investigations were begun through the efforts of western Congressmen and Senators in response to a demand for a broad, scientific, and impartial study of certain fundamental questions having a vital relation to the success of irrigated agriculture, which had thus far been neglected by the General Government and which could not be dealt with adequately by State authorities for lack of means.

Among those were the legal and social questions created by the diversion and use of rivers in irrigation, and which made necessary a radical change in the laws and policies which had hitherto controlled the water of streams in the humid sections of the country. The growing litigation and controversy over water titles showed the need of a better understanding of the legal and economic principles

which should govern the relation of irrigators to one another. In the rapid diversion and use of streams in irrigation by private enterprise, the fact that irrigation is an organized industry had in a measure been lost sight of, and actual development had outrun the creation of administrative regulations and social and economic institutions needed to give stability to titles to water and prevent controversy and litigation, which was retarding development and agricultural prosperity in many sections of the West. Both State authorities and the representatives of the General Government realized that, with the growing use and increasing value of water, it was necessary to begin to gather the facts needed to bring about an intelligent solution of these questions. As these matters involve agriculture, engineering, and economics, they can only be studied by men of special capacity and experience.

The gathering of facts must include the whole country, and the work must be carried on under the direction of men having an acquaintance with the conditions and needs of the whole country. Even if the States had had the means to make these investigations, it was impossible for any State working alone to determine a policy which would have general application. The General Government's direct interest in this question was because of its ownership of large bodies of land which are being irrigated by private enterprise, and the fact that the General Government must sooner or later deal directly with interstate water-right controversies made it necessary that the facts should be gathered by agents freed from any local or sectional influence and interpreted with respect to the needs of the country as a whole.

The work was made a part of the Office of Experiment Stations because this made possible a simple and direct cooperation with a large body of experts who were dealing with these problems on the ground, and who were in a position to reach directly the irrigators most concerned, and to bring directly home to farmers the work done by the Department. Two State agencies for the promotion of irrigation development stood in especial need of this aid. These were the State engineers' offices and the State experiment stations. The State engineers in the administration of the water law, and the State experiment stations in the solution of the agricultural problems of irrigation, were compelled to deal with questions about which there was little accurate or definite information, and which their means would not permit them to obtain.

They, therefore, welcomed the assistance of the Department of Agriculture because it strengthened their hands and made their work more efficient. So far as the State experiment stations were concerned, it not only made possible an extension of their investigations, but it furnished an agency for unifying methods of experimentation for different stations cooperating in a study of the leading problems, under which duplication is being avoided, unity of method secured, and the educational value of the work of each station improved because of convenience in comparing the results of experiments in widely separated localities. This cooperation of the Department with the stations in studying irrigation and drainage questions is, therefore, directly analogous to the work being done in plant production and other branches of agriculture.

The national legislation for the institution of such researches has therefore naturally recognized the agricultural colleges and experiment stations, and a large part of our work in irrigation has been and is carried on in cooperation with these institutions in the several States and Territories. Since the colleges and experiment stations are in close touch with the practical irrigators and farmers in their several communities, it has thus been easier for the Department to bring its work on irrigation home to the large number of practical men for whose benefit this work is carried on.

In organizing its work in irrigation, the Department has followed the lines on which most of its operations are conducted, and has thus had no difficulty in working out a field clearly differentiated from that of the hydrographic division and reclamation service of the Geological Survey. The hydrographic division has for its field the determination of the water supply of the United States available for irrigation, manufacturing, and other purposes. The reclamation service is charged with the construction and operation of great dams, reservoirs, and canals for the irrigation of restricted areas of the arid region, chiefly included in the public domain.

The Department of Agiculture neither determines water supply nor constructs or operates irrigation works. Its duty and privilege are to study the methods for the distribution of irrigation water to farms and for the application of this water to crops, and, in general, utilization of water in agriculture, whether under private or public auspices, throughout the United States. How to make the most of the limited water supply available for irrigation by using it to the best advantage in the production of crops is the task which chiefly engages the attention of the irrigation experts of the Department of Agriculture.

This involves not only studies of the cost of a water supply and of preparing land for irrigation, the methods of applying water to crops, and how to prevent waste of water by seepage and otherwise, but also investigations of drainage systems required to remove surplus water, the machinery needed to secure water (pumps, windmills) to prepare land, to make and harvest crops, and the most complete utilization of the rainfall on the dry areas contiguous to the irrigated areas, the most advantageous crops to grow, and other strictly agricultural problems. In doing this work, the Office of Experiment Stations cooperates with the Weather Bureau, Bureau of Plant Industry, Bureau of Chemistry, and any other branches of the Department, through which it is possible to so extend investigations as to make them meet to the fullest degree the needs of farmers practicing irrigation in the West or in the East.

The extent of the irrigation work of the Department of Agriculture is shown by the fact that during the past year it included field work in 30 States and Territories and in the Hawaiian Islands and Porto Rico.

Mr. COOPER. How many States did you say?

Mr. TRUE. Thirty States and Territories.

According to Bulletin 16 of the Census Bureau the number of irrigated farms in the United States in 1902 was 134,036, aggregating 9,487,077 acres, which have been supplied with water at an expenditure of $93,320,452.

The CHAIRMAN. What is that amount?

Mr. TRUE. That is, in three years 23,480 farms, aggregating 1,704,889 acres.

The CHAIRMAN. Sixty thousand acres per year?

Mr. MEAD. No; 600,000.

The CHAIRMAN. Excuse me, I mean 600,000.

Mr. TRUE. Yes. Since 1902 agricultural settlement and the extension of irrigation have gone on more rapidly than ever before. This is brought out in the last report of the State engineer of Colorado. In 1903 and 1904 there were begun in Colorado, under private enterprise, 1,093 ditches, having an aggregate capacity of 37,817 cubic feet per second. In the same time filings were made for 392 reservoirs, having a total aggregate capacity of 149,586,227 cubic feet. In 1904 over $3,000,000 was paid to Colorado farmers for sugar beets, and over $700,000 paid to factory labor in converting these beets into sugar. Over $10,000,000 has been invested within the past five years in sugar factories in that State, while the total value of all products grown under irrigation in Colorado in 1904 was $40,000,000.

Mr. REEDER. Does that include the expense of procuring and putting that water upon the land?

Mr. TRUE. I do not understand that it does.

Mr. REEDER. What does that ninety-three millions include?

Mr. TRUE. It includes the construction of the——

Mr. MEAD. The main canals.

Mr. REEDER. I was figuring over what it cost per acre, and I thought it was pretty low.

Mr. TRUE. These figures are far below the full expenditures made in reclaiming.

Mr. REEDER. I see.

Mr. TRUE. Yes; I say these figures are far below the full expenditures made in reclaiming, there being thousands of ditches of which there is no official record, and the Census Bureau's figures only include the cost of canals and do not include the expenditures for removing brush, building laterals, and grading land, all of which must be done before irrigation begins. The cost of these items, according to the statistics gathered by this office, has varied from $5 to $30 an acre, making it certain that the total expenditure in providing for the watering of land irrigated by private capital is over $200,000,000.

The value of the crops produced on the irrigated lands in the arid States in 1902 is estimated at $98,468,011. This does not include the rice fields of the Southern States, the cranberry marshes of Wisconsin and New Jersey, nor the valuable products of the market gardens of the Southern and Eastern States. If these were included it would make the total value considerably more than $100,000,000.

The report of the census in 1902 showed that in three years 23,480 farms, aggregating 1,704,889 acres, had been added to the irrigated area.

The CHAIRMAN. Can you tell us how much it costs now, compared with what it did three years ago, to make sugar out of beets?

Mr. TRUE. I have not the figures in mind.

Mr. TIRRELL. They were claiming when we had the great controversy in the House that they had got it down so as to make beet sugar at 3½ cents a pound. Now, this development of the industry has in-

creased so rapidly that I did not know but that you could give us the cost at the present time.

Mr. TRUE. No, sir; I have not got it myself.

Mr. COOPER. Do I understand from these figures as to Colorado that the total growth of the sugar beet in Colorado is due to irrigation?

Mr. TRUE. It is grown under irrigation.

Mr. COOPER. Could it be grown at all without the aid of irrigation?

Mr. TRUE. I do not understand that it could.

The CHAIRMAN. Would you allow me to state right there that the report of the State engineer of Wyoming is just out? I have a copy of it here, and if you will allow me, I will give it to the stenographer and put it in the hearing.

I will state to the committee that the State engineer reports that the records of his office show that the per cent of failures on the part of applicants is small. He says: "If all the work provided for by the permits issued during the past two years is carried out, 907,915.64 acres of land will be reclaimed, at a total cost of $2,274,023, or $3.05 per acre. This will be accomplished by the construction of 2,242 miles of canals and ditches and the storing of 276,758 acre-feet of water in our reservoirs."

Mr. TRUE. Yes; I will be glad to have that inserted. I have just a brief statement along that line, only a little different.

Mr. TIRRELL. And that is two-thirds of the whole territory of Massachusetts and more.

Mr. REEDER. Is it?

Mr. TIRRELL. Yes.

The CHAIRMAN. Those are the applications of two years.

Mr. REEDER. Oh, yes; I see.

Mr. TRUE. Now, during the last two years applications for more than 500 new ditches and canals were made to the State engineer of Wyoming.

In Idaho, between March 11, 1903, and November 1, 1904, 1,285 applications for permits to use water were received and 900 permits were issued. The combined capacity of these canals is 27,951 cubic feet per second of water for irrigation and domestic purposes and 76,000 cubic feet per second of water for mining and power purposes. The land described under the irrigation canals aggregates 1,672,132 acres. In other words, the permits issued for private works in Idaho during a year and a half exceed the entire aggregate of the acreage to be reclaimed under the Government reclamation works thus far approved.

The CHAIRMAN. Exceed what, did you say?

Mr. TRUE. They exceed the aggregate of the acreage to be reclaimed by the Reclamation Service under the projects already approved. As I understand, they expect to reclaim a little over a million acres—a hundred thousand acres over a million.

A wave of immigration is peopling the broad stretch of semiarid country east of the Rocky Mountains between the Gulf of Mexico and Canada. Many of these settlers wish to irrigate part of their land, a large percentage must do so, and this is bringing about an era of irrigation development by means of pumping from wells and of gravity irrigation from small storage reservoirs.

Nearly all of these immigrants are from the East and know

nothing whatever of irrigation methods. The Office of Experiment Stations is making a special effort to lessen their perplexities and meet their needs by preparing popular bulletins showing how to prepare land for irrigation, how to install and operate pumps, how to build and protect small reservoirs, and how to make the best use of the water supply. Through the series of Farmers' Bulletins which are issued in very large editions and distributed mainly by members of Congress, the Department is enabled to make this information readily available to a very large number of people.

Mr. REEDER. Are these bulletins listed in the regular list of bulletins?

Mr. TRUE. Yes, sir. During the past five years irrigated agriculture has made a remarkable advance along the Gulf coast.

The CHAIRMAN. While you are talking of bulletins, Doctor, let me interrupt you just a moment to say to the committee that some of these publications which the gentlemen, in their modesty, call "bulletins" are, as a matter of fact, exceedingly valuable contributions to the science of irrigation, and I hope the gentlemen will take the time to go over them. One publication, for instance, The Use of Water in Irrigation, is a classic on the subject of the use of water in the irrigation of lands, and in my opinion it is the most exhaustive and thorough work of that kind ever published in the world.

Mr. REEDER. Are they all bound in this form?

The CHAIRMAN. Have you any further copies of that bulletin, Doctor True—The Use of Water in Irrigation?

Mr. MEAD. We have them.

The CHAIRMAN. That is bound in cloth?

Mr. MEAD. Yes.

Mr. TIRRELL. What is the number?

Mr. MEAD. I will tell you what I will do. I will send the members of the committee a complete set each.

The CHAIRMAN. This work is very valuable in giving information relative to the volume of water required in a given locality, as indicated by actual practice in the application of water. The Department went into this very thoroughly. How many different measurements did you make? How many are indicated in that work?

Mr. TRUE. A large number.

Mr. MEAD. Over a thousand.

Mr. MARSHALL. These are not all Farmers' Bulletins. They are of two classes.

Mr. MEAD. The best of them are not Farmers' Bulletins. They are published under the head of the Department publications that are intended for distribution by the Office of Experiment Stations.

Mr. REEDER. I wish you would include a list of those publications. My people are interested in this subject.

Mr. COOPER. The people in my district do not know what irrigation is.

Mr. MARSHALL. There are two classes of these bulletins, and the most valuable class are the ones that are not printed in such large numbers as Farmers' Bulletins. You can get an unlimited number of the Farmers' Bulletins, but your number of these most valuable ones is limited.

Mr. COOPER. I do not think I have been able to get hold of them. I sent out over 18,000 Farmers' Bulletins last year. I make it a point to get all the late bulletins that come out, and I start out with the late publications—all those that I think will be of interest to the people in my district, and I send out large quantities every year. Of course, irrigation is not a subject in which our people are interested.

Mr. TIRRELL. I have made up my mind that we do not know anything about politics in the East. [Laughter.]

Mr. TRUE. I was simply referring to the bulletins which have been prepared especially for the newcomers in the field of irrigation. The larger bulletins are more elaborate——

Mr. MARSHALL. And more technical?

Mr. MEAD. No, sir; they are not more technical. No, sir.

Mr. MARSHALL. I have read several myself.

Mr. MEAD. Here is the point: A Farmers' Bulletin is practically limited to twenty or thirty pages. There are a great many things connected with irrigation practice that you can not get into that number of pages It is largely a matter of pages.

Mr. COOPER. You put in as many as eighty or one hundred pages, I notice, in some of the Farmers' Bulletins.

Mr. TRUE. They try to hold us down as much as they can.

Mr. MARSHALL. You could take these larger ones and run them into a number of bulletins?

Mr. COOPER. That one on your good-roads proposition—I sent out several thousand copies of it, and it made for me a great deal of trouble Everybody wanted me to be for that Brownlow proposition in consequence of reading that bulletin.

Mr. TRUE. Now, taking up a little different field of work; during the past five years irrigated agriculture has made a remarkable advance along the Gulf coast. Tobacco and truck farms are being irrigated in Florida; sugar and rice in Louisiana and Texas. Nearly all the water utilized in this region has to be pumped, and more than $5,000.000 has been expended in pumping machinery within this period.

Mr. COOPER. By whom?

Mr. TRUE. By the farmers.

Mr. COOPER. Not at public expense?

Mr. TRUE. No, sir; it is all private work.

Now, the high cost of machinery and of the water lifted makes a knowledge of how to distribute and use it to the best advantage of especial importance. It has also created a number of important legal and economic questions connected with the adjustments of rights to water from streams. The practical value of the reports on rice irrigation and pumping has been recognized by both irrigators and the commercial and business interests of that section, and the extension of these investigations has been urged by associations of rice growers, the New Orleans Board of Trade, and many other important bodies.

Thus far the National Government has not irrigated any land, except a few acres on Indian reservations, but the Reclamation Service has recently announced that it hopes within a few years to have about 1,000,000 acres under reservoirs constructed with the reclamation fund. The information which the Department of Agriculture is collecting and distributing will, of course, be available to the officers of the Reclamation Service and to all farmers who take up land re-

claimed by the National Government. It is, however, evident that, at least for many years, the chief business of the Department as related to irrigation will be to obtain and supply information to the people who are irrigating land at their own expense and entirely under private auspices.

Outside of the Government work, as we have seen, is a very large field, and that will be the field which we must occupy, at least for a long time.

The direct management of the irrigation and drainage investigations of the Office of Experiment Stations has from the outset been committed to Dr. Elwood Mead, whose training and experience have peculiarly fitted him for this work, and I am very glad that he is now to have an opportunity to explain to this committee what is being done under his direction for the advancement of the interests of the irrigating farmers of this country.

The CHAIRMAN. Now, Doctor True, we are very much obliged to you for that statement. Unfortunately we now have only fifteen minutes left until the time for adjournment arrives. That is a very short time in which to hear from Mr. Mead, but that is all we can give him, unless we could have an adjourned meeting. However, the committee will be very glad to hear from Mr. Mead.

Mr. TRUE. I have not gone much into details.

The CHAIRMAN. I know that. We shall be glad to hear from Mr. Mead.

I want to say for Mr. Mead that there can be no question but that he brings to this work a higher knowledge of irrigation laws and practices, both in the United States and in the world at large, than is possessed by any other American, so far as I know, and I have had occasion to go into that matter very thoroughly. He has given that subject a great deal of attention for many years, going into the question of irrigation laws and irrigation practice and irrigation methods and all those things that relate to the use of water in irrigation, not only as to the laws and customs and practices under which the water rights are acquired and the water distributed, but also as to the practices under which the water is used.

Now, Mr. Mead, we shall be very glad to hear from you.

STATEMENT OF MR. ELWOOD MEAD, CHIEF OF IRRIGATION INVESTIGATIONS, DEPARTMENT OF AGRICULTURE.

Mr. MEAD. I have brought with me some of the results of our work in 1904, but it will be impossible to cover the field of this work in the time that is allowed, and, therefore, before I begin, I would like to know whether you prefer that I select some of the leading features with the idea that this is to be our last hearing. If there is to be an adjourned meeting, I will deal with it in a different way.

Mr. MARSHALL. Why could we not have another meeting to-day? I understand they will take up the naval bill in the House to-day.

The CHAIRMAN. Take up the naval bill to-day?

Mr. MARSHALL. Yes; I am told so.

Mr. REEDER. You can call up the Speaker's room by telephone and learn.

The CHAIRMAN. We have very little time now. I am very anxious to have the members of the committee here when we do hear Doctor Mead, because, gentlemen, he thoroughly understands this feature.

Mr. MEAD. I would be very glad to go over the subject, so as to give you some idea of the conditions that prevail in irrigation as it is being developed to-day.

The CHAIRMAN. If we could have a meeting this afternoon for about an hour it would give Mr. Mead an opportunity to go very thoroughly into the subject, and I further want to talk with the members as soon as I can in regard to this matter of a trip. We have not even time to do that now.

Mr. MEAD. Let me take up one feature of irrigation practice that will consume about as much time as you now have.

Our work in irrigation practice divides into two lines: The development of the best methods for the people who are already irrigating, and the diffusion of information concerning that subject among beginners.

People have had to take up this matter of irrigation and learn by experience. Beginners have largely copied what they found in the districts where they settled. If the practice was bad they have copied it. Each valley is isolated in a measure, and the people who go into a particular locality may not realize whether it is a good or a bad practice that they are following.

Now, part of our work is the diffusion of information regarding what is good practice.

The CHAIRMAN. Now, Mr. Mead, if you will excuse me just a moment, because I have to leave, Monday is our regular meeting day, and I can not imagine anything more important to the members of the committee than to hear Mr. Mead at length upon this matter, at least for three-quarters of an hour or an hour. If we can have that time on Monday, he can finish his brief statement now and conclude it on Monday, provided it is possible for the members of the committee to be here on Monday.

Mr. TIRRELL. If we could have a meeting at 11 o'clock on Monday it would give ample time.

The CHAIRMAN. Yes; and I want to go pretty thoroughly into the details about that trip this time.

(At this point the chairman of the committee retired from the room and Mr. Tirrell assumed the chair.)

Mr. MEAD. Then I will be with you on Monday.

I will take up to-day the methods we follow in reaching these beginners. We have in our regular force of field agents about forty-five people, and, as Doctor True pointed out, we are cooperating with nearly every agricultural experiment station in the arid region. There is at each of those stations some one who is giving especial attention to irrigation. We have arranged so that these men are organized into a working body. Every season we take up some feature of irrigation practice about which there is need of a better understanding, and during that season, in connection with our other work, but not to the exclusion of other things, we take up the collection of information regarding that feature of irrigation practice.

Last year we took up the cost of preparing land for irrigation and the methods of applying water to the land. In collecting this infor-

mation we had our field agents in every arid State observe the methods where land was being made ready for irrigation. These studies were supplemented by interviews with people who had done the largest amount of work, to get the actual cost and descriptions of the tools employed and the method adopted for the application of water. Those reports, in the aggregate, represented the results of hundreds of actual improvements in the preparation of hundreds of farms for irrigation, and the cost of that work ranges from $2.50 to $35 an acre for the grading.

In the selection of the methods it was entirely a matter of accident whether the man had hit on the plan best suited to his locality, because the irrigated territory is not continuous. It is a series of oases in the surrounding solitude, and settlers in each of these oases usually follow the plan of the first irrigator.

In one valley, where 275,000 acres of land are being brought under irrigation, farmers were following one method of preparing land to the exclusion of all others. It is a valley where the growing of beets promised to be profitable. It is a valley where diversified farming is necessary in order to maintain the fertility of the land. Yet the method adopted is only suited to one crop and will not permit of beet growing at all. It happens that this crop is now the most profitable one that they can grow. However, it will cease in time to be the most profitable, and when diversified farming is adopted they will have to change their whole system of irrigating. Our bulletin describing different methods of preparing land and applying water met the paramount need of these settlers, as it does that of thousands of other beginners.

We have distributed 8,000 copies of that bulletin in California alone.

I have given you one illustration of the methods by which our work is being carried on in collecting the results of practical experience. Last year we took up the methods of water measurement. The farmer who irrigates finds his bill for water one of his heaviest expenses. There was paid last year altogether about $20,000,000 for water, and hence the method of measurement is a matter of very great importance, in order that men may get what they pay for, and that they will understand and feel that they are getting what they pay for, to the end that controversy shall be avoided.

Now, the majority of farmers can not take a work on hydraulics, with its complicated formulas, and compute the discharge of their lateral or measuring box, but they can take a report that describes in simple language how water is being measured from existing ditches and explaining the conditions which affect the accuracy of this measurement and apply this information to their own case.

Mr. TIRRELL. I want to inquire why all those bulletins were distributed in California alone. I understood you to say 10,000 copies were printed and 8,000 distributed in California. That would leave the rest of them in the Department here?

Mr. MEAD. In the first place, California paid $5,000 to help obtain that information.

Mr. UNDERWOOD. Doctor, I hate to leave you in the midst of your talk, but I must go to the House. I hope to hear you later on Monday.

Mr. MEAD. Yes; California paid $5,000 in aiding this work. This was the particular information which they needed, and they needed it for this reason: People have gone into the State very rapidly, and every man that went in to irrigate must prepare his land as the first step toward growing a crop.

Mr. TIRRELL. Went in where?

Mr. MEAD. The district I was speaking of in referring to California.

Mr. TIRRELL. Where is that?

Mr. MEAD. On the Tuolumne River. It is the Modesto and Turlock irrigation district. It is a municipal district, where the money necessary for carrying on the work was raised by selling bonds, and the bonds were made a lien on the canal. The same rapid development is going on in another part of California, where a canal system, which had water turned into it in December, will water over 200,000 acres of land. That land has all been cultivated heretofore without irrigation. It has all been improved with fences, farmhouses, and barns, and people are going in from Nebraska and Iowa and from all over the East to begin a new form of agriculture there. It will be very easy to injure that land by the injudicious application of water, and it is very easy for these people to make a great mistake by adopting the wrong methods and applying the water improperly. And it was that urgent demand which seemed to require the diffusion of this information.

Mr. TIRRELL. Would the committee like to go on now?

Mr. MARSHALL. I would like to go on the floor myself.

Mr. REEDER. When we adjourn, let it be until half-past 10 o'clock on Monday.

Mr. MARSHALL. Or, say, 11 o'clock.

Mr. REEDER. I move we adjourn until half-past 10 o'clock on Monday.

Mr. TIRRELL. Very well; without objection, it is so agreed.

Thereupon, at 12.05 o'clock p. m., the committee adjourned until Monday morning, February 13, at 10.30 o'clock.

COMMITTEE ON IRRIGATION OF ARID LANDS,
HOUSE OF REPRESENTATIVES,
Washington, D. C., February 13, 1905.

The committee this day met at 11 o'clock a. m., Hon. Frank W. Mondell, chairman, presiding.

The CHAIRMAN. Gentlemen, I presume we might as well continue hearing Mr. Mead on the matters which he has been discussing.

STATEMENT OF MR. ELWOOD MEAD, CHIEF OF IRRIGATION AND DRAINAGE INVESTIGATIONS, DEPARTMENT OF AGRICULTURE.

Mr. MEAD. Mr. Chairman and gentlemen of the committee, in order that I may not get too far away from my subject I have written out my statement, which, however, I will not attempt to read in its entirety, but will refer to some figures which I would probably get wrong if I quoted them from memory merely.

The act of Congress defining the scope of the irrigation and drainage work of the Department of Agriculture has been changed but little since its beginning eight years ago. The paragraph in the appropriation for 1906 reads as follows:

Irrigation and drainage investigations: To enable the Secretary of Agriculture to investigate and report upon the laws of the States and Territories as affecting irrigation and the rights of appropriators and of riparian proprietors and institutions relating to irrigation and upon the use of irrigation waters at home and abroad, with especial suggestions of the best methods for the utilization of irrigation waters in agriculture, and upon plans for the removal of seepage and surplus waters by drainage, and upon the use of different kinds of power and appliances for irrigation, drainage, and other agricultural purposes.

It will be seen that this includes two lines of investigation. The first relates to water rights, the administration of streams and canals, and the social and economic relations of irrigators to each other. The second deals with the practice of irrigation and includes methods of providing a water supply, distributing it among irrigators, and the improvements in irrigation practice, both in preparing land and applying water.

The drainage work in the irrigated district deals with the restoration to production of lands that have been injured by overirrigation or swamped by seepage water. On the legal and economic side it has to do with the organization of drainage districts, the determination of the principles which should govern the ownership and disposal of seepage water, and the determination of assessments and benefits where the work is carried out under district or municipal control.

As the drainage work in the humid States is somewhat foreign to the duties of this committee, it will not be referred to further than to say that there are about 100,000 acres of land now unproductive which can be reclaimed through dikes and drains and which if reclaimed would have a productive capacity equal to four times that of the State of Illinois. During the past year we have made studies and reports on the drainage of a number of districts which have led to the beginning of agricultural drainage by private enterprise to cost in the aggregate more than $2,000,000.

The vital relation which the irrigation work of the Department of Agriculture bears to the progress of agriculture in more than half of the United States can be illustrated by giving a brief review of the development of irrigation along the South Platte River in Colorado during the last thirty-five years.

This river drains the eastern slope of the Rocky Mountains in northeastern Colorado. Irrigation from the main stream and the seven principal tributaries began at about the same time and extended in the same manner. There were first small ditches, then larger ones, then the small ones were made broader and longer, and so, on the main river and each of its feeders the acreage watered grew from year to year, and at the same time more water was withdrawn for towns and for factories. Less than ten years after the founding of the Greeley colony the increased acreage, coupled with wasteful use of water, had brought a shortage on the main stream and on each of its branches. Crops under the lowest ditches began to be ruined by drought. Farmers who had been giving their whole attention to overcoming physical obstacles woke up to the fact that a water title was as necessary as a land title if there was to be any stability or

peace in irrigated agriculture. Without definite titles and some public regulation the man at the head of the stream could take what he pleased, the man below must get along with what was left.

When this question confronted the irrigators along the South Platte they had to deal with it as an urgency problem. Something had to be done to stop warfare between neighbors and save crops. In order to establish private rights to water they had to set aside inherited ideas and prejudices and abrogate the common-law doctrine which had hitherto controlled the water of streams. In setting up a new government they had to determine what was each man's share and how it should be fixed. Should it be measured by the acres of land watered or by the size of the ditch? Should water belong to the individual as personal property, to use or sell or lend to others, or be a right of use only, limited to a definite ditch or specified tracts of land?

To deal with the whole of the main stream and its seven branches seemed too large an undertaking, hence the main stream was divided into three districts and each of the seven branches was made a district, and water rights in each one of these restricted areas were settled without regard to their relation to rights on other parts of the stream; even within the district they were not established wisely, but ignorantly and mistakenly, as was disclosed when a better understanding of the duty of water and the relation which irrigators should bear to each other was reached.

This settlement availed for a half dozen years only. Then it was discovered that if the holders of rights on the head of the main stream and on the seven branches continued to extend the use of water, rights in the middle and lower districts of the main stream had no value, and that to protect these rights the river and its tributaries must be treated as a unit. Legislation to accomplish this was secured, but the irrigators on the main branches had in the meantime built ditches to utilize all the water. Through injunctions against officials and through other delays which an ingenious attorney can devise, the irrigators on one tributary have prevented the enforcement of this law for sixteen years. In the meantime water has become valuable. Rights which at first sold for $5 now bring $35. Water is now too costly to waste or supply without measurement, but when measurement began it was found that the rights first established were a sorry misfit. Because of carelessness and lack of knowledge of how much water was needed for an acre of land, some appropriators had been given ten times as much water as they were entitled to.

The misfits in the adjudications had been carried into the early water contracts of canal companies. Some had agreed to give farmers enough water in a season to cover their land 7 feet deep; others gave about one-fifth this amount. When companies and irrigators began to compare notes all were dissatisfied.

Irrigation has created seepage streams in what were formerly dry channels. Five hundred appropriations of seepage water have been made along the main river. The question arises: Does this seepage water belong to the canal company which created it or to the man who captures it? It is an important question. Canals are being dug to intercept it. This prevents its getting back into the stream, interferes with the doctrine of prior rights, and raises a score of difficult legal and economic questions. There has been lawsuit after law-

suit, but the courts have wobbled so amazingly that irrigators are as far as they were in the beginning from knowing the doctrine which will ultimately prevail.

In the meantime factories have multiplied. They are large users of water. A single factory in Colorado, neglecting to acquire rights by appropriation, has recently paid $225,000 for the rights of an irrigator. Factories which believe they are entitled to water by reason of early use now seek to establish those rights by legal process. They were not included in the original adjudications. Only irrigators and domestic users were represented. Now rights to mines and factories are being established, and a complete readjustment of titles to this water supply is inevitable.

Mr. REEDER. Let me ask this question, as to that water which the factory bought: After they use it, does it go on to the irrigators below, or do they consume it?

Mr. MEAD. It is practically consumed.

Mr. REEDER. How do they manage to consume it?

Mr. MEAD. The company I referred to is the Colorado Fuel and Iron Company, and a great deal of the water they consume goes up in steam.

Mr. COOPER. And I suppose the balance is so contaminated and foul that it is not fit for use in irrigation?

Mr. UNDERWOOD. I reckon they reuse it.

Mr. MEAD. Yes; what is left.

The South Platte is not wholly a Colorado stream. It runs into Nebraska. Originally the entire stream ran into Nebraska. That State adheres to the doctrine of riparian rights. Can the riparian landowners in Nebraska assert that doctrine as against the irrigators of Colorado? If they can, another readjustment is inevitable.

The South Platte is a typical valley. In every State and Territory in the West the same great questions are pressing for solution, and the more intelligent the farmers the more valuable the irrigation work, and the higher the cultivation of the soil the greater is the anxiety for a definite solution of these questions and the more the injury wrought by the ferment that impending change creates. It was this overshadowing need for a knowledge of facts and for the working out of answers to these questions in the early years of development while institutions were forming which created the irrigation work of the Department of Agriculture and made the study of the laws affecting irrigation and the rights of riparian proprietors its first duty.

Mr. BELL. Have they not got the suits to the highest courts?

Mr. MEAD. Yes; but the decisions of the highest courts are not consistent with each other.

Mr. BELL. Have any of the cases been taken to the United States Supreme Court?

Mr. MEAD. No, sir. You see the issues are confused with so many other factors that the decisions do not go to the same point. For example, one suit will be brought by later proprietors, who may claim that this water should go back to the main channel, and another suit will be brought by a ditch company——

Mr. BELL. A large body of proprietors would be affected by this recent law. A question would arise there as to the confiscation of private property and the destruction of private rights, and I should

think they could get that suit before the Supreme Court of the United States.

Mr. COOPER. Take, for example, the laws so far as my State is concerned, governing the right to take water. In damage suits growing out of the destruction of water supplies, in order to establish your rights, you have to clearly trace the channel. You can not guess at it. You must establish the fact that it was your water, and you must trace it definitely.

Mr. BELL. That was not the point I had in mind. Mine was a strictly local question. The State passes a statute now, readjusting the whole situation and attempting to make men give up a certain portion of water which they have been using in order that others may enjoy a portion. That is a fair question, I think, that could be determined absolutely in a court of last resort.

The CHAIRMAN. Is it not true, Mr. Mead, that the tendency of legislation has been toward public control of the waters used in irrigation, and is it not a fact that up to quite recently in some cases the courts have been inclined to make their decisions upon past precedents, and that they have rather leaned the other way?

Mr. MEAD. There is no constitutional question in this case. That has never been contested. It is an illustration of the ingenuity of the legal profession. It always comes up on a new issue every year, so that the points presented and passed upon are not the same, and no classification or harmony can be produced from the different decisions.

Mr. BELL. They shift their grounds, do they?

Mr. MEAD. Yes. It is entirely a question of technicalities.

Mr. REEDER. I would like to ask you, How many rights have been filed on these seepage cases? You stated it a while ago, but I have forgotten.

Mr. MEAD. Five hundred on the main stream. I do not know how many on the tributaries.

Now, as irrigation has been extended and water has become more valuable, the construction of storage works has been found to be profitable. At first those storage works were filled always by surplus water. They were filled at a time when irrigators did not need the water. But the stored water is most valuable at the time when the streams are dry, when the crops are about to be destroyed, when water is measured by the value of the crop; so that stored water, where it is for sale, commands high prices, and storage reservoirs have been the most valuable irrigation property in the State.

Hence the construction of storage reservoirs has gone on until there are more storage reservoirs than can be filled by taking the surplus water, and so purchases have been made of the early rights for direct irrigation for the purpose of filling these reservoirs at a time when the irrigators need water from the stream; and that has begun a new question.

Furthermore, the reservoirs themselves number about 200 on this stream, and the rights or the claims as between themselves to the possession of the water create a new class of priority rights.

Mr. REEDER. Are these 200 reservoirs on the main stream alone?

Mr. MEAD. No, sir. Those 200 are on the main stream and on the tributaries together. A single one of those storage reservoirs has run

into millions of dollars of cost. I do not know whether it is $1,000,000 or $2,000,000, but I know it is a large sum. That reservoir will hold the low-water flow of the main stream for six months.

You can see here how new questions have come up with new developments, how the farmer who went there first had nothing but physical obstacles to overcome, and how his claim to his water rights and to the stability of his water rights has been constantly undergoing change. The latest contention is over the division of water between States, and the lower States are considering the necessity of State action to protect their citizens.

Mr. REEDER. Which State is that?

Mr. MEAD. So far as the South Platte is concerned I refer to the State of Nebraska.

Mr. REEDER. As against what State?

Mr. MEAD. As against Colorado. There we find this further difficulty, that the laws of Nebraska are different from those of Colorado. It is not a case of two sets of rights under the same kind of statutes, but it is two sets of rights based upon a different theory of ownership in two different States. You have not only the question of adjusting prior rights, but the question of adjustment of owners.

Farmers can not ascertain what are the probable or possible evolutions to be created by increasing use, nor how these are to affect the stability and value of their homes, because their horizon is in a large measure bounded by their fields. The people of one locality can not determine how their interests are to be adjusted with those of remote sections. And when we reflect that some of the rivers of the arid region run for thousands of miles through three or four States; that the rights to water include mining, manufacturing, domestic use, irrigation, and navigation, and involve the doctrines of personal ownership, usufructuary rights, and the common-law riparian doctrine, it becomes manifest that only the National Government, working along the broadest lines and looking not simply at a temporary adjustment but toward a system suited to the needs of the remote future, can bring order and system out of this uncertainty.

Mr. BELL. Is the reclamation service going into that branch of it yet?

Mr. MEAD. Only so far as it affects their own projects.

Mr. BELL. This is the Department of Agriculture?

Mr. MEAD. Yes. We are dealing with this from the standpoint of the large number of irrigators who are already using water.

Mr. BELL. From the agricultural standpoint?

Mr. MEAD. Yes.

Mr. REEDER. Is the suit between Colorado and Nebraska of the same character as the suit between Colorado and Kansas?

Mr. MEAD. There is no suit between Nebraska and Colorado, but many of the arid States are awaiting the outcome of the suit between Kansas and Colorado.

The first step toward a rational settlement seems to be a knowledge of facts. First of all, in determining what can be done with a river it must be known how much water is needed for an acre of land. There are now over 150,000 irrigated farms. If water rights are to be based on use, we must know how much is needed, not simply in one locality, but in scores of localities. Lack of this information when rights on the South Platte were established made it possible

for some irrigators to secure water enough to cover their land each season to a depth of 150 feet and others only enough to cover their land to a depth of 3 feet. Extended and continuous measurements of the water used in irrigation are needed to guide the courts in adjudicating water rights, because when an adjudication is made without this knowledge, every one tries to be sure of enough water by claiming all that his ignorance or greed leads him to believe he can ever use. The result is rights which aggregate more than the stream's flow; efforts to hold the excess by improvident use, which injures land and robs others: attempts to derive profits from the sales of surplus water, thus destroying the principle of priority and laying securely the foundation for vexatious and costly litigation.

Our investigations of the duty of water were begun by measuring the quantity used by irrigators under ordinary practice. Where this practice seemed defective our reports called attention to it and suggested a remedy. Now, we are determining what quantity should be used to give the best results. How wide the variation is between good and bad practice is shown by the following figures:

The first year we measured the water used from the Sunnyside Canal enough was delivered to irrigators to cover the land to a depth of 10 feet. Improvements in practice suggested by reports of this office and put into effect by the canal company reduced the quantity used in 1904 to enough to cover the land to a depth of 6 feet, or a saving of 44 per cent.

There is room for further improvement, as there are numerous evidences of overirrigation. In the Turlock district, in California, enough water was turned into the head of the canal in 1904 to cover the land to a depth of 8.34 feet. Enough was turned on the fields to cover them to a depth of 6.84 feet. In the Modesto district in 1904 enough water was turned into the canal to cover the land to a depth of 13.18 feet, and enough was turned on the land to cover it to a depth of 11.13 feet. This wasteful use of water is filling the soil and will in a few years make drainage necessary unless corrected.

In southern California, where the season is longer and evaporation greater, the water turned into the Gage Canal would cover the land irrigated to a depth of only 2 feet, or about the quantity lost in seepage under the Turlock Canal. The Gage Canal and its principal laterals are cemented. Here is a difference between saving and wasteful use of water sufficient to cover the land to a depth of 11 feet.

Mr. Cooper. Is not the rainfall there greater?

Mr. Mead. It is three times greater.

Mr. Bell. They have the whole Tuolumne River there, and they simply turn it loose.

Mr. Mead. When we began our measurements of the duty of water in New Mexico the amount used by the irrigators in one valley varied from 2 to 15 acre-feet for each acre irrigated, and the average of the measurements for three years was between 6 and 7 acre-feet for each acre. Acting on the recommendations of our report, the management of one of the largest canals in this valley has changed his water contracts so as to provide 2 acre-feet of water for each acre of land, but agrees to furnish an additional quantity for an additional charge. During three years no farmer has paid the additional charge, yet the average crops are larger, injury from seepage water has been avoided, and farmers are better satisfied than under the old wasteful method.

When we reflect that irrigators paid last year over $20,000,000 for the water they used, the saving in water charges alone which is being brought about through better methods of application is amounting to an enormous sum, yet this is nothing as compared to the improvement in crops and the prevention of injury to land through excessive use of water.

Mr. UNDERWOOD. There is no section of this country where 15 feet of water is needed to raise a crop, is there?

Mr. MEAD. No; but there were sections of country where from 10 to 15 feet of water was being continuously used.

Mr. COOPER. Did it not ruin the land?

Mr. MEAD. That was the tendency; yes.

Mr. COOPER. What would be the effect of that less use of water? Did it improve the agricultural conditions, or did it injure them?

Mr. MEAD. It improved them very materially. There is, however, a point beyond which economy should not be pushed, as reduced yields more than offset the saving accomplished. The following figures show this:

A field of barley in California, which received the natural rainfall only, produced 9 bushels to the acre; an adjoining field, given 16 inches of water by irrigation in addition to rainfall, produced 22 bushels to the acre. One field, given 4.5 inches of water, produced straw, but no grain; an adjoining field, given 8.5 inches of water, produced 10 bushels to the acre, while a third field, given 24.5 inches of water, yielded 38 bushels to the acre.

In Nevada a field of wheat, receiving water to a depth of 1.85 feet, produced 4 per cent more grain than one receiving 1.45 feet. A field of oats, receiving water to a depth of 2 feet, produced 14 per cent more grain than one irrigated to a depth of 1.68 feet.

Irrigated lands in southern New Mexico and Texas require more water than irrigated lands in Montana and Idaho. In New Mexico tests of the effect on yield of different quantities of water showed that there was a continuous increase in yield with the increase in the quantity of water received, beginning with 36 inches and going up to 65 inches, the tract which received 65 inches producing 39 per cent more hay than the one receiving 3 feet.

Mr. TIRRELL. What is the average amount of water that these lands require, if there is an average?

Mr. MEAD. That is what we are endeavoring to find out. The average under existing practice is about 4 feet measured at the head gate and about 2½ feet measured in the field.

The CHAIRMAN. The difference is lost by percolation.

Mr. BELL. I heard Senator Newlands say in a general statement the other day that if you have enough water in New Mexico now to irrigate 100,000 acres, after you have irrigated 100,000 acres for a few years you will have water to spare for other lands. I construed it that way, at least, but wondered how true that was.

Mr. MEAD. In the beginning of irrigation a large amount of water is absorbed in filling up the subsoil. When irrigation began in Kern County, Cal., one had to go 70 feet to find water. But to-day one can get water within 6 or 7 feet.

Mr. BELL. But that water that you find is water that has gone in there?

Mr. Mead. Yes, sir. The studies of the duty of water outline a class of investigations directed toward the betterment of conditions in the older settled sections of the West. Let me now take up a line of work which is being carried on for the benefit of beginners. The first thing which confronts the settler on arid land is the material obstacles he must overcome. He must clear his land, lay out his laterals, determine their size and grade, and the method by which water is to be spread over his fields, and must prepare his fields in accordance with the method adopted. If left alone, he will in time find out how to do these things, but it will be a discouraging and costly training and it is wholly a matter of accident as to whether or not the method he adopts is best suited to his conditions. As a factor in arid-land reclamation this has an importance not generally recognized. We have done valuable work to aid the engineer but not enough for the farmer. Every year the number of settlers who begin this apprenticeship runs into the thousands. It is manifest that if they could be given intelligent direction and be placed in a position to avail themselves of the accumulated experience of the past fifty years, there would be a saving in labor, a saving in water, and a lessening of the time required in bringing farms into full production, which add materially to the growth and prosperity of irrigated districts.

To render this assistance, we organized our force, and the agencies cooperating with us in the different arid States and Territories, as explained on Saturday, into an information bureau which is gathering and publishing the experience of irrigators in the different features of irrigation practice. Each year and in each State our agents or associates find out from the best irrigators of that State how they carry on certain features of irrigation practice.

Nor are such collations of the results of practical experience in widely separated sections of the country of value to the beginners only. In many places they are modifying the methods hitherto followed. One fact will illustrate this: Flooding from small laterals is the system of applying water in use in three-fifths of the arid region, but there are districts where this method is entirely unknown and where the publication of this bulletin was the first information these farmers had that such a simple method was feasible.

Among the features of irrigation practice about which our organization has gathered information may be mentioned the construction of current wheels, methods of measuring water, use of cement and concrete to take the place of wood in irrigation structures, and cost of pumping water for irrigation and the factors which affect this.

The studies of irrigation by pumping in 1904 had a wide range. They included statistics of the cost of pumping from over 1,000 different stations. At some of these, field records were kept showing the quantity of water raised, the number of acres irrigated, the amount of fuel used, with its cost, and the value of the crops grown. These field studies were supplemented by laboratory tests to show the efficiency of different makes of pumps. Altogether these studies embraced nearly every kind of power and about every type of pump, varying in size from windmills costing less than $100 and discharging a stream a half inch in diameter to pumping stations costing over $100,000 and discharging a stream 4 feet in diameter. The fuel in-

cluded straw, brush, coal, wood, gasoline, and crude petroleum; the power, steam engines, gas engines, windmills, and electric motors.

These comprehensive studies of pumping were undertaken because the best authorities agree that not over 10 per cent of the arid region can be irrigated from streams. The use of the remaining 90 per cent in agriculture depends in large measure on obtaining water to irrigate from some other source than streams. There is the further fact that improvements in machinery have so lessened the cost of pumping that many farmers are resorting to it where it is possible to obtain water from gravity canals.

During the past season the office has been conducting investigations to determine the possibilities of storm waters and underground waters as supplemental sources of supply. The collection of storm waters requires the construction of reservoirs, while the securing of underground supplies requires pumping. It is believed that by the use of these two methods it will be possible for the owners of the homes on the plains to raise sufficient fruit, vegetables, and forage to provides themselves and their work animals with a food supply which will carry them over years of drought, and thus enable them to maintain their families during those years where heretofore they have been compelled to abandon the land to avoid starvation. It will also add greatly to the comfort and pleasure of ranch life by providing a good supply of fresh vegetables and fruit for household use and render possible the raising of fruit and shade trees, which will make ranches attractive.

Wherever possible, the data given in the reports of the agents of this Office as to the cost of pumping water have been reduced to a form showing the cost of raising 1 acre-foot of water 1 foot. In most instances fuel cost only is given, although in some cases the cost of attendance and incidental expenses are included. The average cost of raising 1 acre-foot of water 1 foot for 53 pumping plants located in California, Colorado, Kansas, Arizona, and Texas is 3 cents. The average lift for these same plants is 45 feet, making the average cost per acre-foot at the surface of the ground $1.35. This includes several kinds of fuel—wood, coal, distillate, crude oil, gasoline, and electric power. These data are brought together in the following table for the purpose of comparison:

Place.	Cost of raising 1 acre-foot of water 1 foot.	Average lift.	Cost of 1 acre-foot of water at ground surface.
		Feet.	
California	$0.066	78.2	$5.16
Arizona	.053	37.1	1.97
Texas:			
Near El Paso	.043	40.0	1.72
Near San Antonio	.026	46.0	1.20

Leaving now the work in which all our agents have cooperated, I will briefly review some of the special investigations carried on in the different States, and will begin with California, where more than 2,000,000 acres of land is now being irrigated, where land and water have a value reached in few, if any, other places in the world, and where practically every irrigation question which has to be dealt

with in the United States has assumed greater or less importance. In this work we are being aided by the State, which two years ago appropriated $10,000 to be expended under our direction.

In southern California the long hot summers cause evaporation to be a serious source of loss of water. Certain conditions in southern California make it highly desirable that this should be lessened as much as possible. The great value of land and water in that section has caused irrigation to be extended until now only the best practices will make it possible to continue to irrigate the land now under cultivation. This condition of affairs prevails in certain parts of the Los Angeles, San Gabriel, and Santa Ana valleys and some of the districts around San Diego. In some of these valleys the ground water has been lowered 60 to 70 feet by pumping, and in a few instances 200 feet.

For several years the late William Irving, engineer of the Gage Canal, conducted experiments for our office to determine the best method of distributing and applying water in the Santa Ana Valley. In 1905 similar work will be carried on at Pomona in response to the following request of the farmers' clubs of Pomona and Claremont, where a single pumping plant, now being constructed, is to cost $300,000.

Whereas owing to lack of general knowledge of mechanical principles as applied to pumping water, the cost of water for the maintenance of our horticultural pursuits is becoming excessive: Therefore, be it

Resolved, That the Department of Agriculture be, and hereby is, requested to obtain and furnish correct and reliable data as to the present status of water development in Pomona Valley, giving the number, location, size, and depth of wells with the quantity of water obtainable therefrom. Also kind, size, speed, and efficiency of pump; kind, power, and running cost of motor, together with such other data as might be of assistance in determining the present status of our problem.

This data should be from tests of centrifugal and other pumps of various sizes under all varying conditions as to lift, speed, and water delivered.

Similar demands for the extension of these investigations are coming to us from all parts of the State, the Farmers' Club of Santa Barbara County having recently sent to the Department the following resolutions:

Whereas in the fertile and deep soil of Ventura County the value of staple crops is increased from two to three fold by the use of water pumped from wells; and

Whereas irrigation investigations are now being carried on by the Office of Experiment Stations of the United States Department of Agriculture in cooperation with the State of California to determine ways and means of reducing the present cost of pumping water and lessening the enormous losses due to soil evaporation: Therefore, be it

Resolved, That we indorse this branch of investigations as being eminently practical and useful and commend it heartily to the liberal support of our representatives in both the State legislature and Congress.

In both these resolutions the importance of pumping has been emphasized. It is not, however, exaggerated. A knowledge of the kind of pump best suited to a specific use and of how to install and operate it affects the profits and success of a large fraction of California's agriculture and horticulture.

Last year our pumping investigations in California included records of 750 pumps and measurement of the water lifted and the acres of land served, with the cost of operation of over 70 pumps. The complete report, which will be published shortly, will give to

irrigators a large amount of practical information on the factors which affect the efficiency of pumping plants and the cost of lifting water.

In the Modesto-Turlock irrigation district in the valley of the Tuolomne River we are dealing with different questions. The canals of these two districts will irrigate 275,000 acres of land. The owners of the land know little of irrigation methods and desire advice about preparing their land to receive water and in working out a system of organization by which water will be controlled and delivered with economy and with certainty that each individual farmer will receive his proper share. As these laterals will aggregate hundreds of miles in length and the measuring boxes at the different farms be numbered by the thousand, the working out of such a system is indispensable to the success of the districts.

The assistance of this office was asked in the spring of 1904. The first step was to provide for measuring and recording the water delivered to different users. The districts have adopted the system we organized. It will furnish a practical guide as to the duty of water and tend to check wasteful or injurious use.

The cost of preparing land for irrigation is varying, from $5 to $35 an acre. A study of the adaptability of the various methods of applying water to the conditions of these districts was begun in 1904 and will be continued on a more extensive scale this year. As about 250,000 acres remain to be prepared for water, the expense of doing this will be somewhere between $2,500,000 and $5,000,000. It is exceedingly desirable, therefore, that the plan best adapted to that section be followed.

It may be explained that there are now in the United States about thirty different methods of applying water to field crops, these being modifications of four systems—flooding, furrows, checks, and basins. The check system is a cheap and effective method of irrigating alfalfa. It is not suited to the irrigation of wheat or sugar beets, and hence is not well adapted to a rotation of crops.

It has not been demonstrated whether flooding or furrows is suited to this soil or the slope of the ground. The first step toward rational progress is to test this, and in cooperation with the authorities of the two districts a tract of land has been secured which will be divided into three tracts, one of which will be irrigated by the flooding system, another by furrows, and another by checks. This will help to determine the relative cost of preparation and of spreading water and the influence on yield. The interest in this demonstration is not confined to the Tuolumme Valley. It will affect irrigation practice throughout the great interior valley of northern California.

In no portion of the West are irrigation possibilities greater than in the Sacramento Valley, and nowhere is settlement proceeding at a more rapid rate. The Central Canal, into which water was turned for the first time in December, covers approximately 250,000 acres of land. Across the river from the Central Canal is Butte Canal, which will irrigate a large area. From Cache Creek a canal is being built to irrigate several thousand acres, and there are a number of smaller projects under construction by private enterprise, making a large aggregate acreage.

More than 90 per cent of the irrigable area of this valley is now under cultivation to nonirrigated crops. It is certain that the in-

crease in productive capacity, population, and wealth which irrigation will bring about is very great. But progress will depend on the adoption of right methods of irrigation and in checking the excessive and injurious use of water. To promote this, the office in 1904 carried on experiments at Chico to determine the quantity of water which gives the best results in that section. This year, in cooperation with the Bureau of Plant Industry, the work will be extended so as to test the relative merits of flooding, furrows, and checks in applying water.

Since the 1st of December we have distributed in California over 8,000 bulletins describing methods of preparing land for irrigation and the cost of pumping.

In Nevada our work in 1904 was aided by an appropriation of $1,000, made by the State legislature. We studied the duty of water and the rise of water in the soil.

There must soon be an adjudication of water rights from the Yakima River in the State of Washington. When this takes place the first questions will be: How much water is needed for an acre of land? How much do farmers use? How much of what is turned in at the head gate is lost by seepage and evaporation before it reaches the farm? The only way to obtain this information is through an actual measurement of the quantity of water used, and this the irrigation interests of the valley asked us to undertake. In response thereto, the water diverted and applied to nearly 300,000 acres of land was measured in 1904.

Numerous tests of seepage losses were also made. A considerable portion of the low lands were threatened with ruin through seepage, and the drainage branch of our service prepared plans for the relief of a number of tracts of this overwatered land. In every instance these plans have proven successful. The source of the surplus water supply was correctly located and the capacity of the drains were ample for its removal. On one hop farm, where the rise of the soil water destroyed the crop in 1903, this investigation located an intercepting drain which was dug by the owner, and the land this year produced a crop worth nearly $600 an acre.

In Oregon there is about 3,000,000 acres of land under cultivation by a rainfall so scanty that any impoverishment of the soil or any serious reduction in the average amount of rainfall means the loss of crops. Here the problem is to devise methods of tillage or methods of conserving the available water supply to meet these possible changes. Here tests are being made of the value of winter irrigation and of methods of tillage to check evaporation.

At Bend, Oreg., an irrigation canal has recently been completed which will water about 150,000 acres of land. Neither the managers of this canal nor the farmers who are settling under it know how much water is needed to irrigate an acre of land. They do not know how the water ought to be applied nor how to organize the farmers under laterals so that each one will get his share of what is turned in at the head-gate. They have agreed that if we will detail an expert to measure the water and determine how much is used and lay out the work to be done they will prepare a number of fields for testing irrigation by checks, by furrows, and by flooding. After a couple of seasons' trial the farmers can proceed intelligently with their improvements. They can not without it.

As irrigation is to have a large extension in Oregon, the early determination of these practical questions means not only a saving of thousands of dollars to farmers, but the ultimate saving of a large amount of water to irrigators and of loss and controversy to canal management, not only under private works, but under the works which the Government will ultimately construct.

In Utah the natural flow of most streams is utilized, so that any further extension of irrigation depends in part on storage, but largely on a better use of the water supply. To bring this about there is need of a scientific study of the water requirements of crops. The work carried on in 1904 in cooperation with the State experiment station included varying the quantity of water applied in irrigation, varying the quantity of water and the time of irrigation to ascertain the effect on the quality and quantity of grain and the cooking qualities of vegetables. Thus far but little success has been had in attempting to grow hard wheat in irrigated districts. The Utah experiments encourage the belief that by skill in the application of water a progressive improvement in this respect can be made. Trials of methods of checking evaporation losses and of the relative merits of flooding, furrows, and checks were also made in Utah.

Utah has over 100,000 acres of land damaged by seepage water. The removal of this water involves problems not met with in the Eastern States, where the surplus water comes from above ground instead of through underground channels fed by losses from canals or overirrigated fields. In many cases, where the source can be located, the cheapest method of relief is by intercepting drains. In Cache Valley, where several thousand acres of land have been rendered unproductive by seepage, we are making experiments to determine the best method of relief. The drainage of the damaged lands of Cache, Salt Lake, Sevier, and Washington counties will bring into production more agricultural land in Utah than anything else involving an equal outlay.

A bill has been introduced in the Utah legislature, and passed the senate with only two dissenting votes, appropriating $10,000 for cooperation with our investigation in continuing these studies for the next two years.

In Idaho, Montana, Wyoming, Nebraska, and Colorado we cooperated with the State engineers' offices and State experiment stations in carrying on investigations similar to those outlined for Utah.

In Texas, Kansas, Nebraska, and the Dakotas, and in sections of many arid States, agriculture will depend in large measure on a combination of irrigation and dry farming. Here the well and small reservoir will in time be relatively as important as they are in India, where 13,000,000 acres are irrigated from wells and 8,000,000 acres from tanks or small storage basins. It is my belief that the well and small reservoir are destined to water a large area in the arid and semi-arid West. The average cost of windmill irrigation in Kansas last year, including expenses for maintenance and operation and interest on the outlay at 7 per cent, was about $6 per acre. The value of the crops grown ranged from $20 an acre for alfalfa to $300 an acre for sweet potatoes. The area irrigated by a single mill varied from an average of 2 acres for the 8-foot mill to 8 to 9 acres for the 25-foot

mill. Whatever are the possibilities of this kind of irrigation, they ought to be determined and the facts given the widest publicity at the earliest possible moment, because thousands of farmers have already gone into a country where this kind of irrigation may be their salvation.

In Texas, Kansas, Colorado, eastern Wyoming, western Nebraska, and the western half of North and South Dakota, as well as much of Montana, men are settling where success must depend on a union of the most advanced practices in dry farming combined, wherever feasible, with the irrigation of small areas. There has been an enormous emigration to this section during the past two years. Along every railroad line reaching into that territory settlement has extended farther and farther west, much as it did in 1884–85. The permanency and prosperity of this settlement are not yet assured. It will be a failure if these farmers attempt to grow the same crops and in the same way as in the East. I believe it will be a success if farmers learn how to conserve moisture in the soil and grow crops suited to that region. This means an evolution in agriculture. In its best form it means the combination of a comparatively large area, varying from a quarter section to a section, to be cultivated by rainfall, with 5 to 20 acres of land irrigated.

The managers of railways traversing this territory are alive to the importance of demonstrating how its resources can be best utilized. They appreciate that the prosperity of the farmers along their roads means their own prosperity, while the failure of these farmers is certain to reflect on their own receipts. Believing in the practical value of the work we are doing, the Union Pacific, Burlington, Colorado Southern, and Northern Pacific railways have each volunteered to aid in testing the feasibility of irrigation by pumping and small reservoirs when combined with dry farming, if this Office will undertake to direct the experiments.

A number of farmers in North Dakota have indicated a willingness to undertake this sort of irrigation if the methods can be explained to them, and a bill making an appropriation for this work has been introduced in the legislature of that State.

We went about this work in the following manner: In Texas three field agents were employed in 1904. They were all trained engineers. Two had had extensive experience in California in the operation of pumping plants for irrigation. One had been engaged for several years as an instructor for beginners in irrigation. Their duties were two fold: First, to give personal advice and direction to beginners as to how to go about irrigating their crops; next, to study the resources of the country, to determine its possibilities, and to ascertain the cost of irrigation and the value of the crops produced. The most valuable feature of the season's work was the personal direction given to beginners in irrigation. In some instances the farmers gathered together in towns and were told how to prepare their land, how to apply water, how to install pumps, and how to care for them. We have had numerous letters from these farmers expressing their appreciation of this service, and stating that through it they had changed their original plans and saved a large amount of money thereby.

IRRIGATION IN THE HUMID STATES.

We have been accustomed to consider irrigation as of importance to the arid portions only of the country, but we are beginning to realize that it is to have a large field of usefulness in the East, especially to market gardeners and the growers of high-priced products. Doctor True has referred to the remarkable extension of irrigation along the Gulf coast. It will in time have a similar development throughout the entire South wherever water can be had at a depth of less than 50 feet. Although irrigation is far more expensive in the East than in the West, the average cost per acre according to the census bulletin being $100 as against $10 for the arid region, nevertheless it has proven profitable. I do not know of a market gardener who has once installed an irrigation plant who has abandoned it, although there are occasional seasons when it is not used, and we have records showing that the number of new irrigation plants established each year is growing rapidly.

The CHAIRMAN. Now, the committee would like to hear from you very briefly on certain other matters—for instance, what have you done to aid irrigation in connection with rice culture in Louisiana, and what have you done as to irrigation in the East?

Mr. MEAD. Here is the first of our bulletins [exhibiting same] on rice irrigation in the South, and that was practically a study of what were the conditions in the rice districts. That study disclosed the fact that there are two questions connected with the development of the rice industry that will affect its continual prosperity. One is the determination of the type of pumps that will lift the water at the least cost, and the other is the determination of the quantity of water that will give the best results. The tendency of irrigators in the rice districts is to use too much water. Too great a depth of water on rice fields retards the action of the sun in heating the soil, makes the growth slower and the stalks weaker and more liable to be broken. The increased depth of water increases seepage, and as all the water has to be drained off at certain times of the year, it increases the cost of pumping, because the more water drained off the more has to be lifted to replace it.

We have also been studying the effect of salt water on the growth of rice and its influence on the subsequent productiveness of fields to which applied. The slight fall of the streams flowing into the Gulf causes salt water to flow upstream for considerable distances when the water is low and large demands made on the streams by the pumps, and in dry years water containing a considerable percentage of salt water has at times been applied to crops. Our conclusions are that water containing a considerable percentage of salt can be applied safely to plants having considerable growth, but will injure very young rice. If not continuously applied it is not likely to have any injurious effect on the soil, because the rains of subsequent years wash the salt all out.

We are also aiding to determine what can be done in growing rice in districts where it has never been tried. Last year we carried on experiments in rice growing in central Arkansas, in the region between Little Rock and the Mississippi River. A district here between 90 and 100 miles long and 30 to 40 miles wide is not well

suited to growing wheat and cotton, but seems to be well adapted to rice. Last year the yields were from 60 to 90 bushels per acre.

The CHAIRMAN. You did some work also in the Carolinas?

Mr. MEAD. Yes, sir. We have made some surveys to determine the cost of providing a supplemental water supply for Cooper River, and some investigations of improvements in methods of building levees and protecting rice fields from freshets. It is difficult, however, to deal with the situation in the Carolinas because they are suffering from a number of causes that are widespread. The matter of stream management we hope to take up and study thoroughly in the near future.

One of the difficulties which the rice planters have to contend with is higher water in freshets and lower water during droughts than formerly prevailed. This is due to cutting off the upland timber and the erosion of soil into the streams, filling up their channels, through the cultivation and washing of the hill lands. Higher water in freshets means higher levees, and these in some places have been raised to the limit of safety. The danger now is that during floods the pressure of the water will cause breaks inside of the levee banks.

The CHAIRMAN. Have you not done some work in New Jersey also?

Mr. MEAD. Yes, sir.

Mr. COOPER. How far north in the Mississippi Valley—in what latitude would it be practicable to grow rice?

Mr. MEAD. It is difficult to say just how far it can be grown profitably. They raise rice in Italy in the same latitude as St. Paul, Minn.

Mr. COOPER. That is on the Mediterranean?

Mr. MEAD. No; it is in the interior.

The CHAIRMAN. In the valley of the Po?

Mr. MEAD. Yes.

Mr. UNDERWOOD. I have shot ducks in rice fields in northern Minnesota, but that is not the same kind of rice, I take it.

Mr. MEAD. I believe rice will grow up to the northern boundary of Arkansas.

Now, taking up the question of the chairman regarding our work in irrigation in the East, there are two lines where irrigation will in time be of large importance. One is the irrigation of market gardens, including cranberries, which is a part of market gardening, and the other is the irrigation of both garden and field crops in the South. Wherever water can be had in the South at less than 50 feet below the surface, it is going to be profitable to irrigate by pumping, because this will make it possible to grow an additional crop each year. You can grow a crop after the first one is harvested if there is water enough to give it an immediate start and keep it growing. The conditions in the South are very much like those in Italy, where with 40 inches of rainfall they spend as high as $200 an acre over large areas to provide an additional water supply. They do this because without irrigation the second crop could not be grown. It would be burned out by the intense heat of the summer.

Irrigation also aids the scientific rotation of crops and enables the farmer to maintain the fertility of his land.

In many parts of Italy, as in the South, irrigation is needed to perpetuate meadows and pastures.

Irrigation has proven to be very profitable in the production of tobacco. I have recently received a list of 50 people who are irrigating garden and field crops in one county in Florida. The extension of irrigation in this section during the past three or four years has been very marked.

Mr. REEDER. They grow a new kind of tobacco there which they are not able to grow by the ordinary process?

Mr. MEAD. I do not know about that. Our work in aiding irrigation in the South has thus far been confined to advising farmers about the kind of pumping machinery they should install and the methods of distributing water over their land. In Georgia, Alabama, and Mississippi farmers are beginning to irrigate field crops, but they need advice about the amount of water required for an acre of land in order to secure pumps and engines and pipe of the right dimensions.

The CHAIRMAN. You have undertaken some work in Texas, Kansas, and other places?

Mr. MEAD. Yes, sir.

Mr. TRUE. It ought to be said also, Mr. Mondell, that there is already quite a little irrigation in New Jersey, Massachusetts, and Connecticut by market gardeners. That is growing from year to year.

Mr. MEAD. Yes. Here [exhibiting bulletin] is a report on irrigation in the humid sections of the country, prepared two years ago. We now have three or four times as many districts where irrigation is important as there were when this report was prepared. The next bulletin will be much more comprehensive and instructive.

I will supplement what was said earlier in this statement by explaining that this year we expect to prepare a report on the methods of building small reservoirs, using our field agents in the same manner as described Saturday for collecting the information. Through the courtesy of the management of the Chicago and Northwestern Railway lines west of the Missouri River, we are to have the benefit of the experience gained by this railway in building a large number of reservoirs to provide stock water in the arid region. They have maintained and operated these reservoirs for several years and have in their possession the details of the first cost and some valuable information regarding the problems encountered in protecting and maintaining reservoirs. One feature of this experience will serve as an illustration. The reservoirs which were so built as to have the embankment on the eastern side have cost far more to maintain than those where the embankment was on the western side. That is because the prevailing winds drive the waves against the bank when on the eastern side and away from the bank when on the western. Banks on the eastern sides of their reservoirs have had to be riprapped and constantly repaired. Banks on the western side have required no protection.

The CHAIRMAN. Now, Mr. Mead, the hour of 12 o'clock has arrived.

Mr. MEAD. I have appreciated, Mr. Chairman, the opportunity to appear before your committee.

The CHAIRMAN. We are much obliged to you for your statement, and we have all been glad to hear it.

Mr. MEAD. I should like to make one brief explanation. The question has been asked as to the manner of distributing our bulletins. I have sent a number of these bulletins to the members of the committee, together with a list of the bulletins which are now available, and I should like to have one of these lists inserted with my statement. They are marked with the price charged by the Superintendent of Documents, but those sent directly from the Department are sent free.

The CHAIRMAN. They are sent on request?

Mr. MEAD. Yes, sir. No charge is made for those sent directly from the Department.

Thereupon, at 12.05 p. m., the committee adjourned.

Recommended for publication.
A. C. TRUE, *Director.*

Publication authorized.
JAMES WILSON, *Secretary of Agriculture.*

WASHINGTON, D. C., *May 15, 1905.*

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